

Fast passive microwave radiative transfer in precipitating clouds: Towards direct radiance assimilation

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Outline

- Introduction

 - OPTRAN versus Eddington (gas absorption only)
 - Accuracy
 - Impact of thermal source terms

 - Including Cloud liquid water/precipitation: First results
 - Biases GFS/AMSU under cloud-free and cloudy conditions
 - First results for precipitation

 - Outlook
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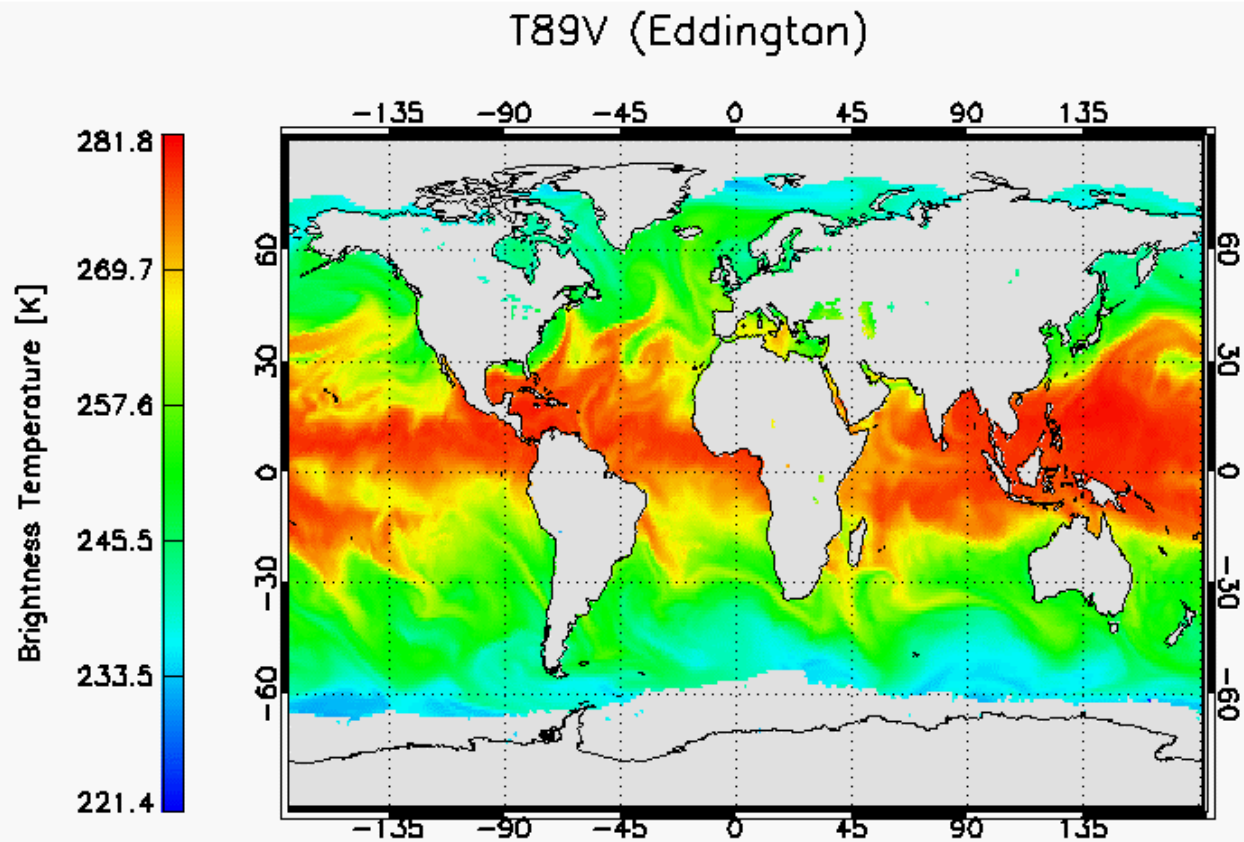
RT models for assimilation in NCEP GFS/GDAS under cloudy/precipitating conditions?

- Surface emissivity
 - Scattering/emission by rain/frozen precipitation
 - Emission by cloud liquid water
 - Has to fit in current operational environment (interfaces etc.)
 - Has to be fast
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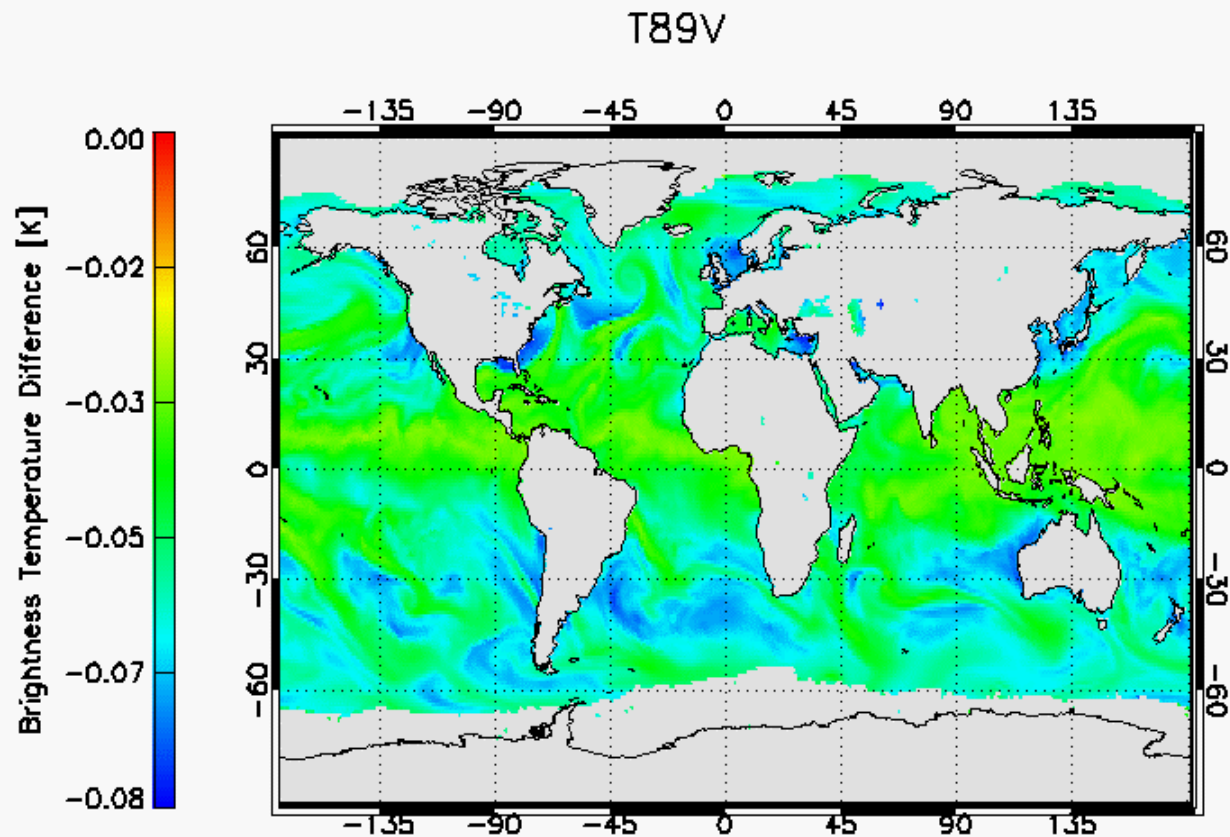
Current status

- Surface emissivity model (FASTEM-II) included in OPTRAN
 - Eddington model (P. Bauer) included in OPTRAN
 - Liquid water absorption included
 - Scattering lookup tables for rain, snow, graupel, hail included
 - Will present first comparison results with satellite data here
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OPTRAN versus Eddington (gas absorption only) (Sanity check for our implementation)

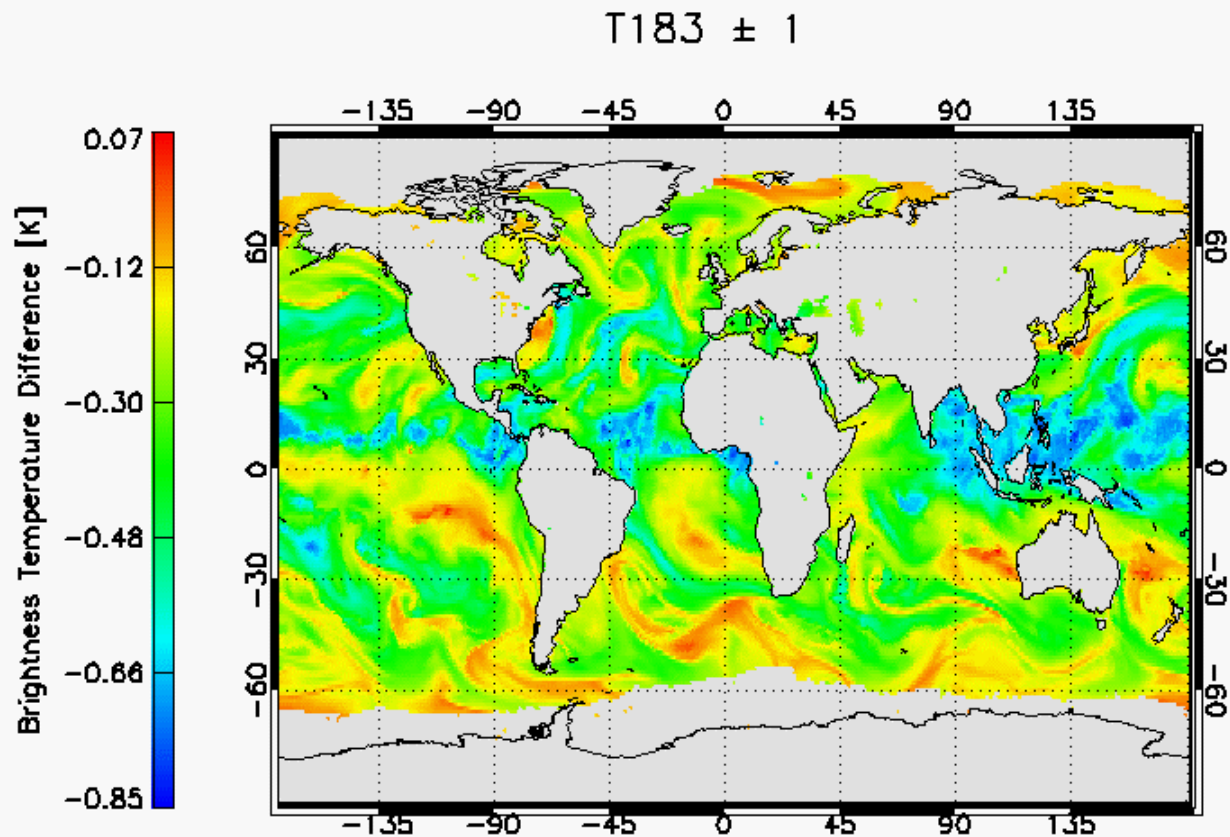


OPTRAN versus Eddington (gas absorption only) Difference 89 GHz



OPTRAN versus Eddington (gas absorption only)

Difference 183 ± 1 GHz (@ 53 zenith angle)

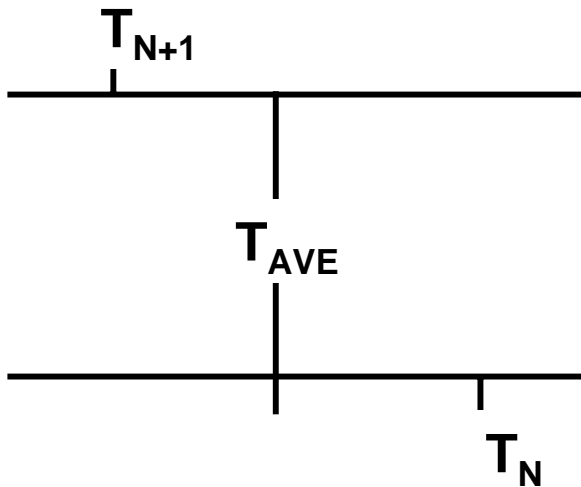


OPTRAN versus Eddington (gas absorption only)

Difference is due to treatment of thermal source term in radiative transfer:

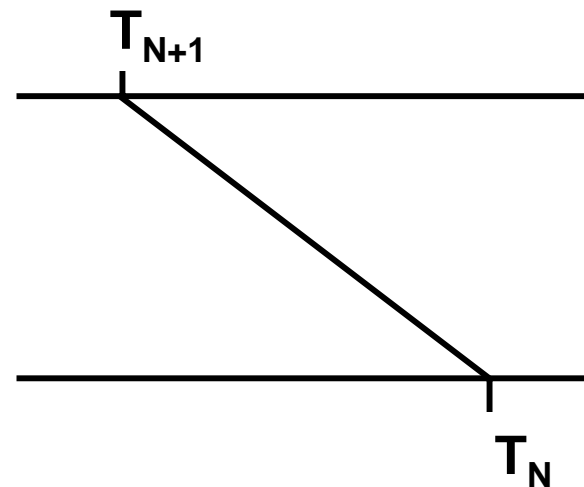
OPTRAN:

Assumes layer average temperature:

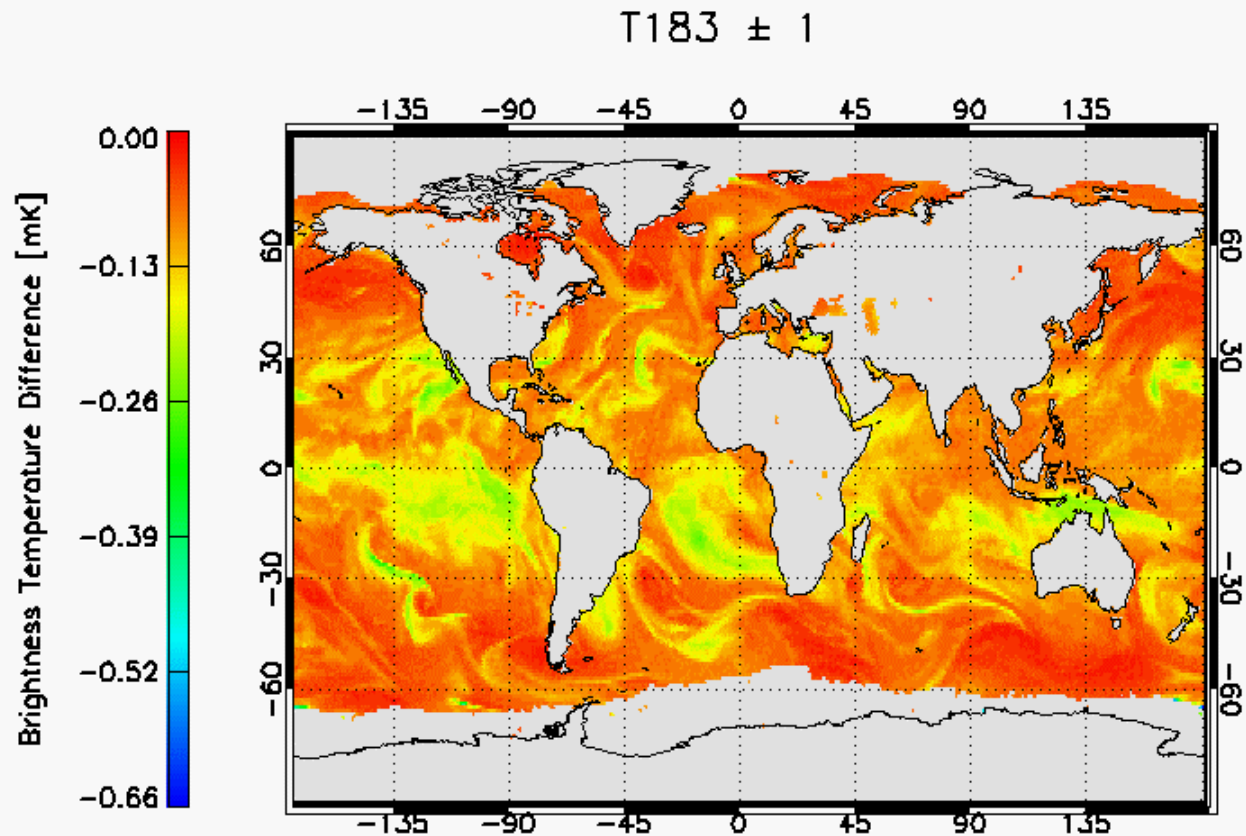


Eddington:

Assumes linear temperature change within layer:



OPTRAN versus Eddington (gas absorption only) Same thermal source term



(Note: Units here is milli-Kelvin)

Differences in thermal source:

- Only important if the upper and lower level temperatures are significantly different AND if the layer is optically thick
 - Differences depend on water vapor and/or temperature fields
 - With increasing model vertical resolution difference approaches zero
 - Both formulations of the thermal source have an analytical solution
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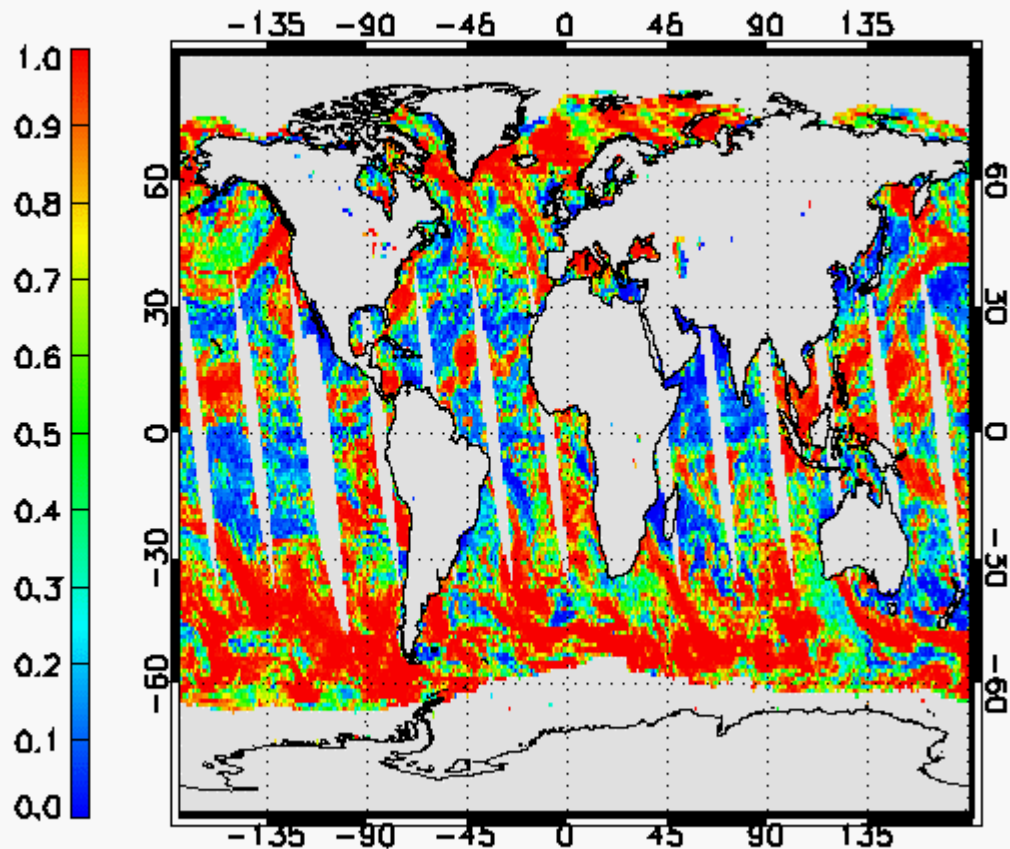
Comparisons satellite/simulations including cloud liquid water

Screening strategy

- Stay within ± 1.0 hours between GFS forecast and AMSU observation
 - Use CLAVR-X (Heidinger, 2003) AVHRR gridded cloud product to find boxes that are at least 95% cloudy (or at maximum 5% cloudy for cloud-free)
 - Compare AMSU-A/B window frequencies and AMSU-B 183 $\pm X$ GHz water vapor absorption channels
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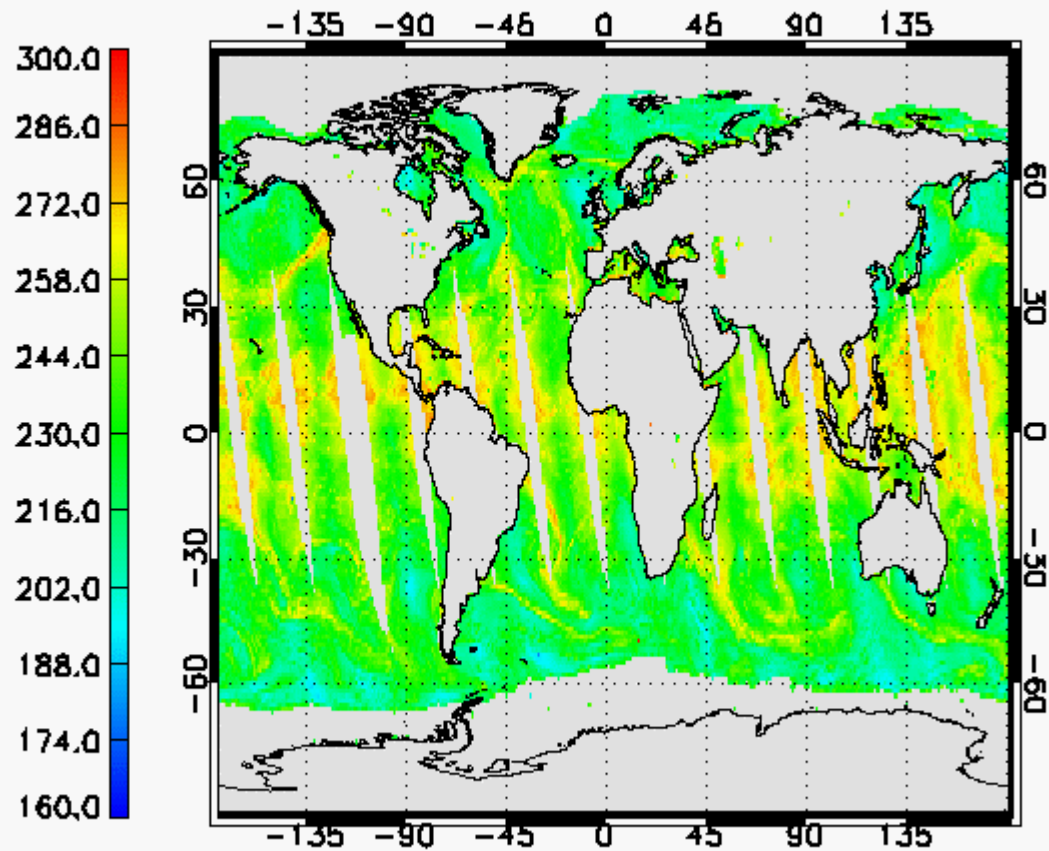
CLAVR-x (Heidinger, 2003) cloud coverage

AVHRR Cloud fraction



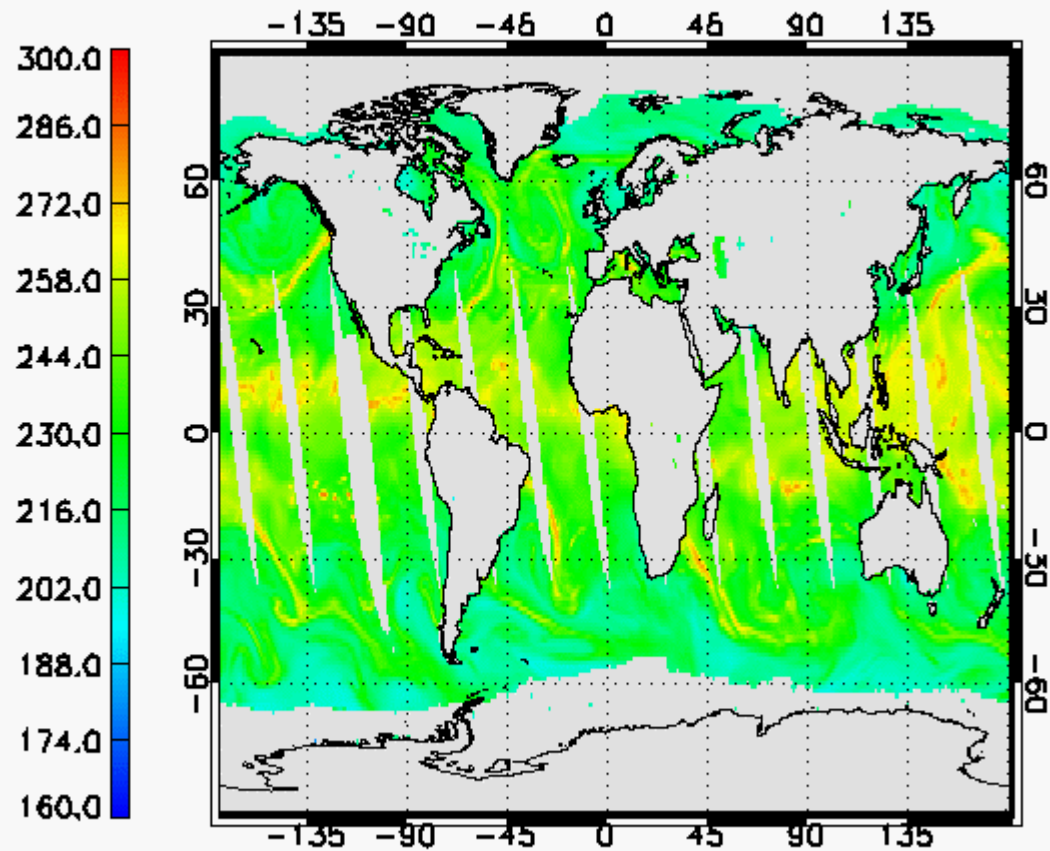
AMSU gridded product (Weng et al.)

N17 AMSU-B T89 [K]

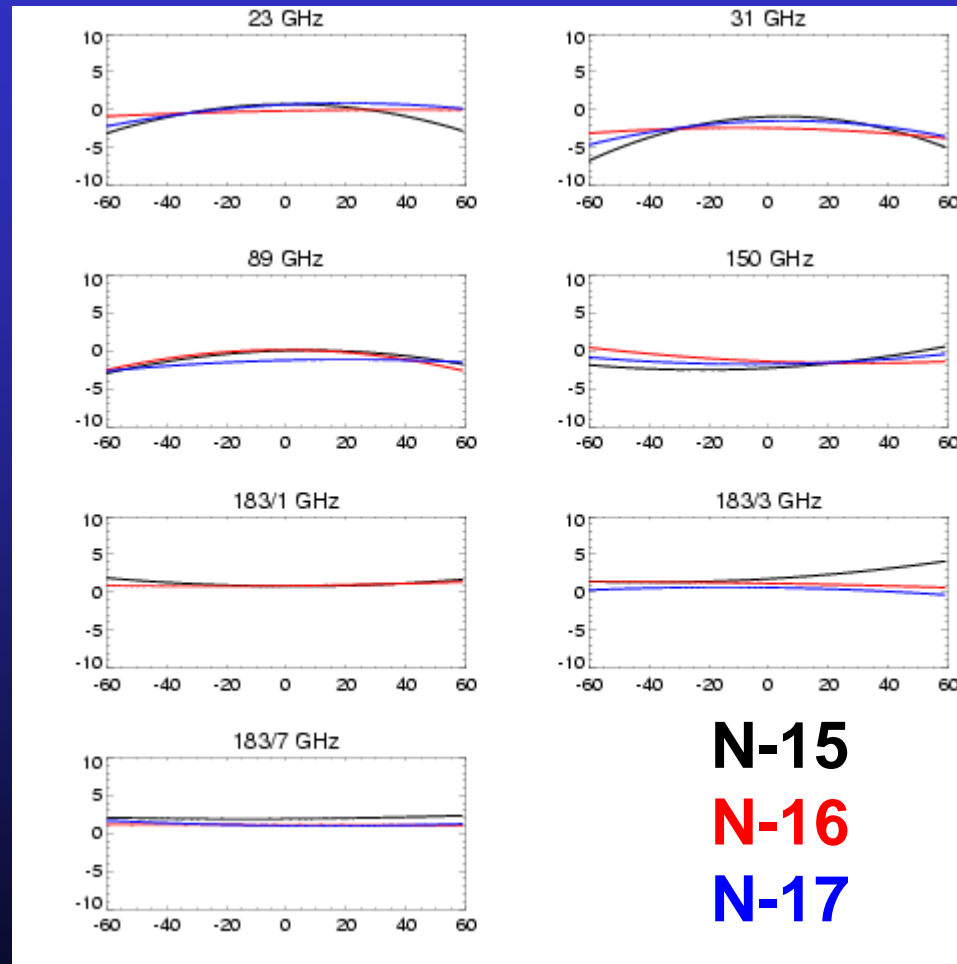


Simulation (gas + cloud water)

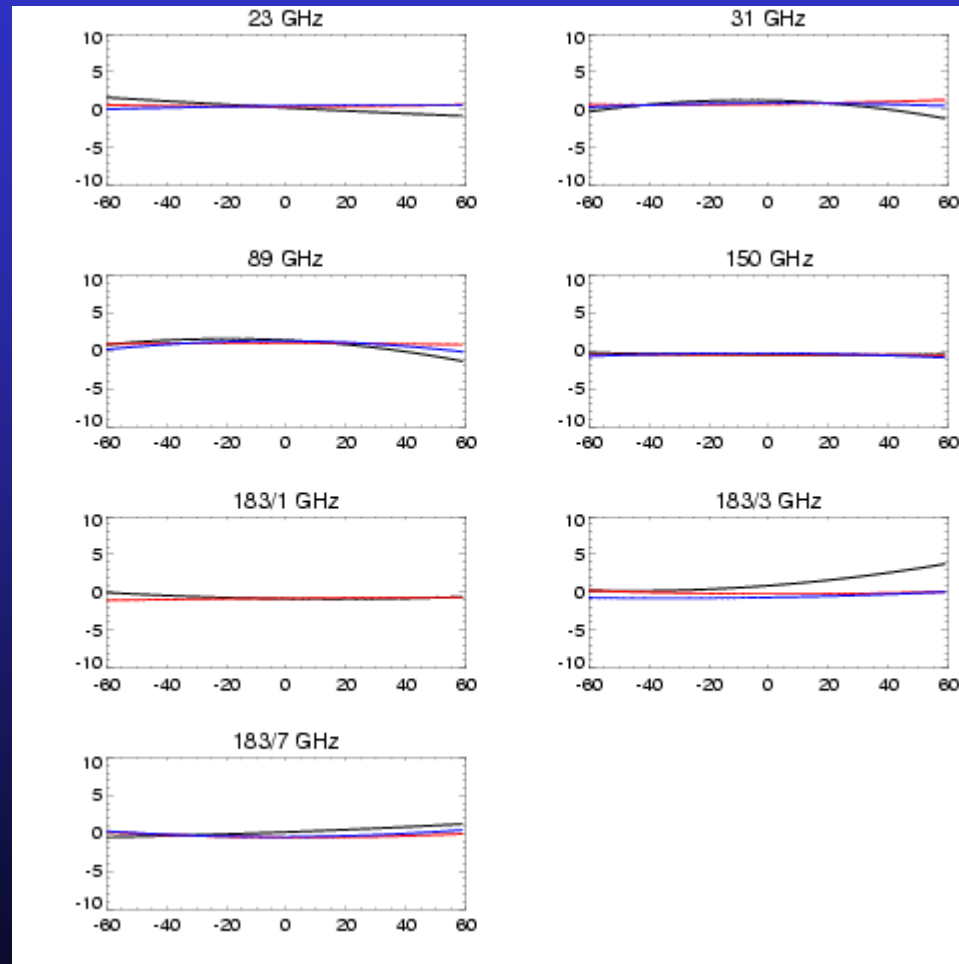
SIMULATIONS T89



First assessment of AMSU-A/B versus GFS biases **cloud-free** (period: 16-19 Oct. 2003)

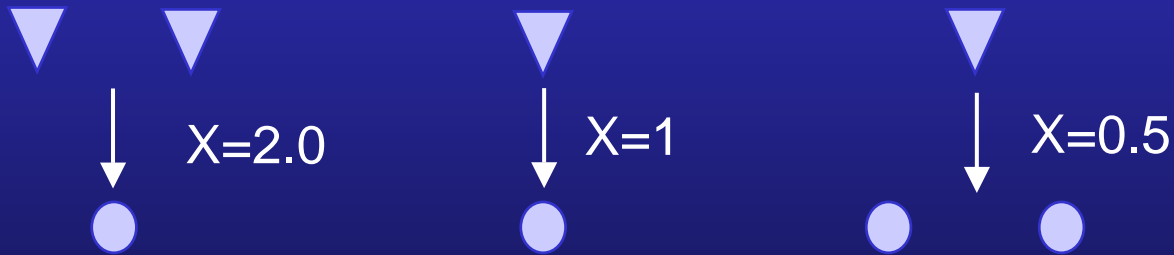


First assessment of AMSU-A/B versus GFS biases **cloudy** (period: 16-19 Oct. 2003)



Precipitation microphysics, what to do with bulk ice?

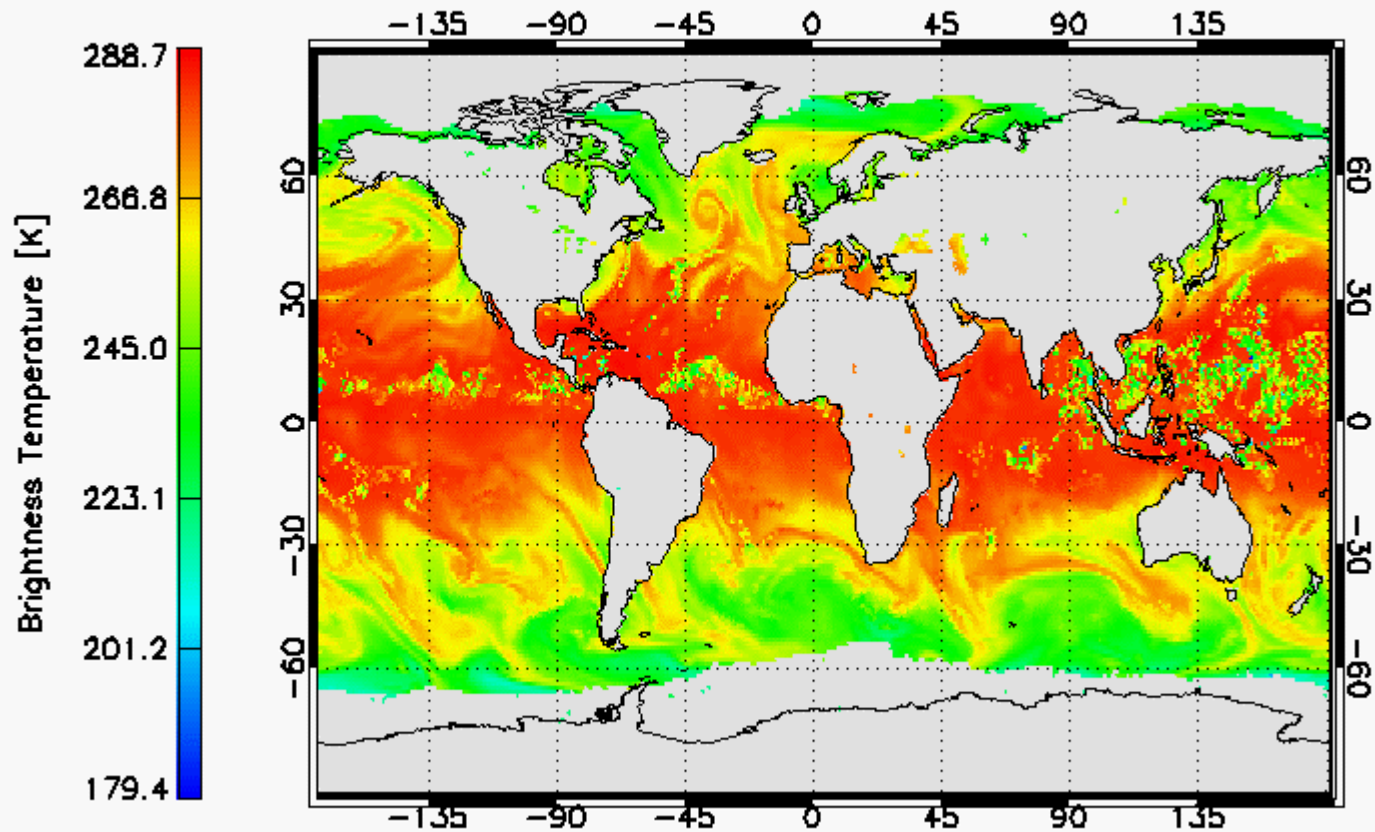
- Both, frozen and liquid rain follow an exponential size distribution?
- Average ice particle diameter may differ from that of frozen precipitation at a given rain rate



- Different ice densities may occur (snow, graupel, hail)
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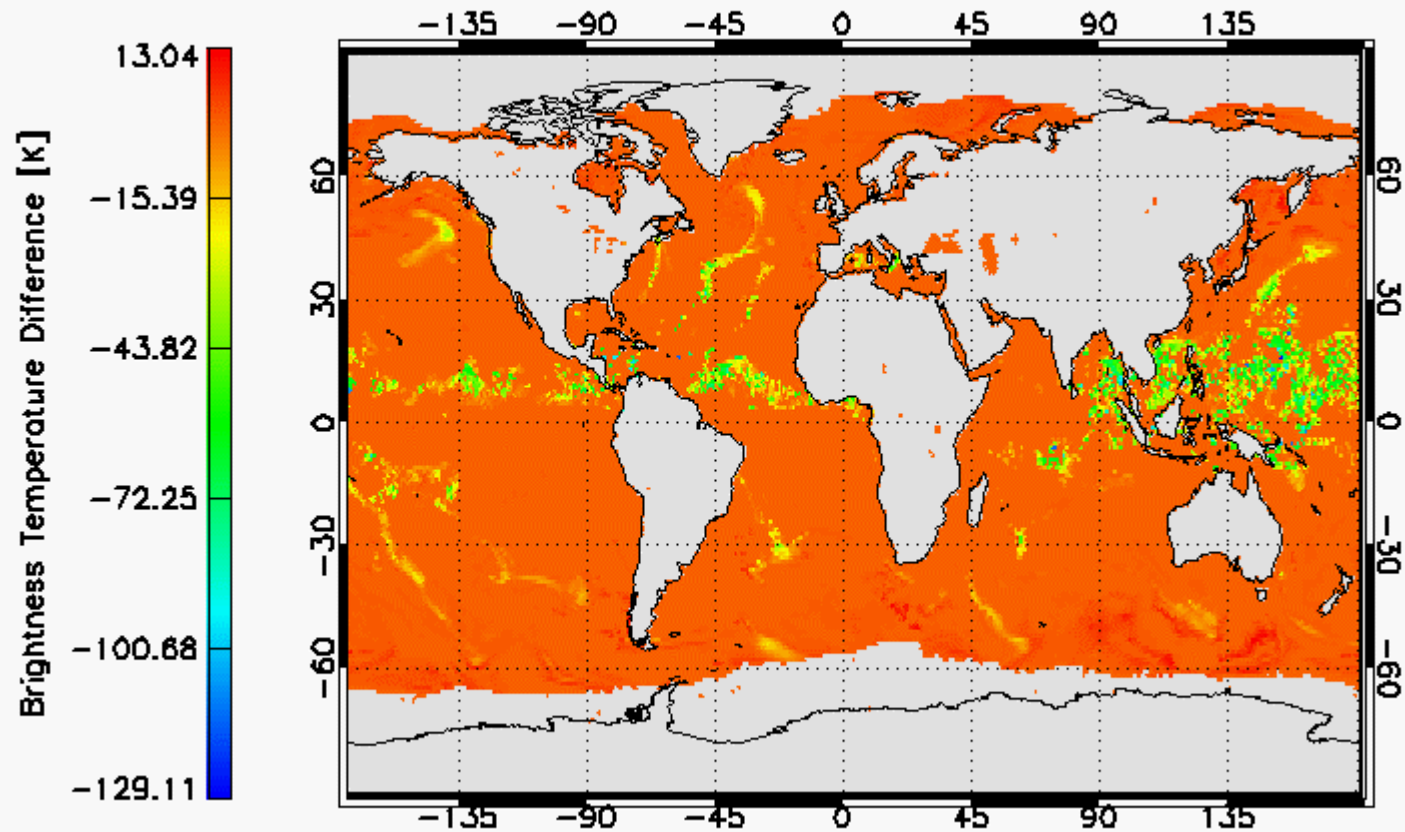
Simulation including precipitation

T150V (Eddington w/Precip)



Difference with - without precipitation

T150V, With - Without Precip



Conclusions

- FASTEM surface emissivity model implemented in OPTRAN
 - Eddington rt-model implemented in OPTRAN
 - Eddington model agrees with OPTRAN in milli-Kelvin range if the same thermal source is used
 - First comparisons with GFS 12 hour forecast fields
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Future plans

- Monitor bias statistics over long time period
 - Inclusion of other radiative transfer models in with other Radiative transfer models:
 - Weng and Liu polarized Eddington model (almost ready, in cooperation with F. Weng)
 - Successive order of scattering
 - Precipitation assimilation:
 - Tangent linear, adjoint model
 - Include cloud diagnostics to generate precipitation rate
 - 1DVAR loop to optimize moisture profiles versus direct assimilation?
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